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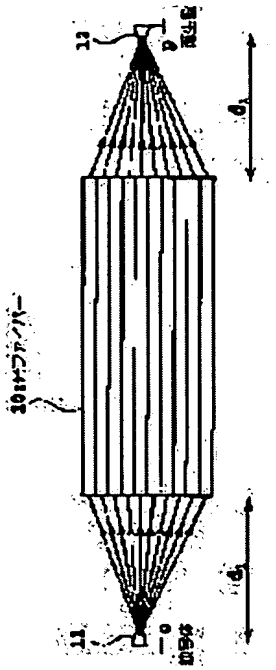
(54) STEREOSCOPIC IMAGE DEVICE



(57)Abstract:
PROBLEM TO BE SOLVED: To display a stereoscopic image on the front of an optical fiber as an aerial image by setting the length of the optical fiber having lens action as the odd-number multiple of the half cycle of an optical path in the optical fiber.
SOLUTION: The optical fiber 10 whose refractive index is higher at its center part in a radial direction and gets smaller toward its peripheral part has the lens action. Plural optical fibers 10 are constituted to have the same two-dimensional arrangement at both ends. The length of the optical fiber 10 is set as the odd-number multiple of the half cycle of the optical path in the optical fiber 10. Light beams emitted from the centers of the end faces of the respective optical fibers 10 are crossed at a position at a distance d1 which is the same as a distance from an incident end to an object 11 on the outside of the optical fiber 10, that is, in the advancing direction of light, and a reproduced image 12 is obtained at this crossing point P. Irregularities are inverted in the reproduced image 12, and this problem is solved by using even sets of optical fiber groups at some intervals in series.

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CLAIMS

[Claim(s)]
[Claim 1] Solid image equipment characterized by making each die length of said optical fiber into odd times of the half period of the optical path in this optical fiber for a stereoscopic model in an image pick-up and the solid image equipment transmitted and displayed by considering as the optical-fiber group which constitutes the same length who has a lens operation, and two or more optical fibers so that it may become the same two-dimensional array at the both ends of the optical fiber concerned.
[Claim 2] Solid image equipment according to claim 1 characterized by using the optical fiber which has uneven refractive-index distribution like a square property in radial as said optical fiber.
[Claim 3] Solid image equipment according to claim 1 or 2 characterized by isolating each optical-fiber group between predetermined, carrying out serial arrangement, using said optical-fiber group even, and picturizing, transmitting and displaying a stereoscopic model.
[Claim 4] Solid image equipment according to claim 1 to 3 characterized by inserting contraction optical system, expansion optical system, or rotation optical system in the field which carries out image formation within the optical fiber concerned when parallel light carries out incidence to the optical fiber of said optical-fiber group.
[Claim 5] Solid image equipment according to claim 1 to 3 characterized by inserting optical multiplication equipment in the field which carries out image formation within the optical fiber concerned when parallel light carries out incidence to the optical fiber of said optical-fiber group.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the optical solid image equipment adapting the so-called integral photography [integral photography (IP)] technique about the solid image equipment which carries out optical transmission of the solid image.

[0002] In addition, integral photography is one of the solid image methods, and uses a microlens like the compound eye of an insect.

[0003]

[Description of the Prior Art] As optical solid image equipment adapting an integral photography technique For example, as shown in drawing 1 , by having uneven refractive-index distribution like a square property in radial etc. The same length who has a lens operation, and two or more optical fibers (gray TEDDO index optical fiber) 10 The die length considers as the integral multiple of one period of an optical path, and the solid image equipment which picturizes, transmits and displays a stereoscopic model (photographic subject) 11 is indicated by Japanese Patent Application No. No. 117355 [ten to] with constituting so that it may become the same two-dimensional array (henceforth a "optical-fiber group") at the both ends of the optical fiber.

[0004] Without making light into an electrical signal according to this prior invention, without enlarging the scale of an optical transmission line for a solid image, it can transmit covering a long distance, and if it manufactures so that an optical fiber can be crooked, it will also become possible for a transmission line to be crooked. Moreover, by inserting expansion, contraction, and an optical multiplication component in the specific location in the middle of an optical fiber, it can also expand and reduce and optical multiplication of the stereoscopic model can also be carried out. Therefore, this precedingly applied equipment is applicable as the endoscope which offers a solid image, a bore scope, etc.

[0005]

[Problem(s) to be Solved by the Invention] However, in the prior invention of above-mentioned Japanese Patent Application No. No. 117355 [ten to], as shown in drawing 1 , the playback stereoscopic model 12 could be generated only behind the end face of an optical fiber 10 (that is, inside of an optical-fiber group), but had the technical problem which should be solved that this stereoscopic model could not be displayed on the front face of an optical fiber as an air image.

[0006] The purpose of this invention solves an above-mentioned technical problem, and is to offer the solid image equipment which enabled it to display a stereoscopic model on the front face of an optical fiber as an air image.

[0007]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, invention of claim 1 is considering as the optical-fiber group which constitutes the same length who has a lens operation, and two or more optical fibers so that it may become the same two-dimensional array at the both ends of the optical fiber concerned, and is characterize by to make each die length of said optical fiber into odd times of the half period of the optical path in this optical fiber for a stereoscopic model in an image pick-up and the solid image equipment transmit and display.

[0008] Here, the optical fiber which has uneven refractive-index distribution like a square property in radial is preferably used as said optical fiber.

[0009] Moreover, preferably, each optical-fiber group is isolated between predetermined, serial arrangement is carried out, using said optical-fiber group even, and a stereoscopic model is picturized, transmitted and displayed.

[0010] Moreover, preferably, when parallel light carries out incidence to the optical fiber of said optical-fiber group, contraction optical system, expansion optical system, or rotation optical system is inserted in the field which carries out image formation within the optical fiber concerned.

[0011] Moreover, preferably, when parallel light carries out incidence to the optical fiber of said optical-fiber group, optical multiplication equipment is inserted in the field which carries out image formation within the optical fiber concerned.

[0012] Since two or more optical-fiber groups which constitute the same length who has a lens operation as has uneven refractive-index distribution like a square property in radial, and two or more optical fibers from this invention so that it may be made for the die length to be odd times the half period of an optical path and the both ends of an optical fiber may serve as the same two-dimensional array mutually are used, a solid reconstruction image can be displayed on the front face of an optical fiber as an air image.

[0013]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained to a detail with reference to a drawing.

[0014] It is [0015] as an example which becomes small as the refractive index of an optical fiber is high in a radial core and goes to a periphery.

[Equation 1]

$$n = n_0 \cdot \left(1 - \frac{A}{2} r^2\right) \qquad (1)$$

n　：半径ｒにおける屈折率　　A：定数

n_0：中心における屈折率　　ｒ：半径

[0016] When light carries out incidence to the optical fiber 10 which comes out and has the property shown, since the refractive index is as high as a radial core (shaft center section), as shown in drawing 2 , a beam of light moves in a zigzag direction, carries out image formation in respect of a certain specification, and has a lens operation. this principle -- 1964 and D.MARCUSE ** -- it is found out and that detail is indicated by The Bell System Technical Journal. (July, 1964) etc. Here, the relation between the beam-of-light matrix of the optical fiber concerned, i.e., the location of incident light, an include angle, and the location of outgoing radiation light and an include angle can be expressed like the following formulas (2).

[0017]

[Equation 2]

$$\begin{bmatrix} r_1 \\ r_1' \end{bmatrix} = \begin{bmatrix} \cos\theta & \frac{1}{n_0\sqrt{A}}\sin\theta \\ -\frac{1}{n_0\sqrt{A}}\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} r_2 \\ r_2' \end{bmatrix} \qquad (2)$$

[0018]

[Equation 3]

ここに、r_1：入射端面における光線の入射位置

r'_1：入射端面における光線の傾き

r_2：出射端面における光線の出射位置

r'_2：出射端面における光線の傾き

$$\theta = \sqrt{A}\, Z_0$$

Z_0：光ファイバー長

[0019] It comes out, and it is and has a relation as shown in drawing 3 .
[0020] With the solid image equipment of ten to 1 l. Japanese Patent Application No. No. 7355 which is invention-in-this-application persons' invention, the image pick-up section and a display are connected, and it unifies, and is the die length Z0 of the optical fiber 10 concerned. [0021]
[Equation 4]

$$Z_0 = \frac{\theta}{\sqrt{A}} = \frac{1}{\sqrt{A}} 2\ (m+1)\ \pi \qquad \cdots (3)$$

m：ゼロ以上の整数

[0022] It carries out, it is arranged and constituted two-dimensional, as shown in drawing 4 , and in the outgoing radiation end face of this optical-fiber group (optical-fiber bundle), it can be made to carry out direct observation of the solid image.
[0023] In the above-mentioned (3) formula, the die length equivalent to theta=2pi is equivalent to one period of the optical path in an optical fiber here.
[0024] In the case of the optical-fiber length which fills the above-mentioned (3) formula, it is r1 =r2 from the above-mentioned (2) formula, and r'1 =r'2. As it becomes and drawing 5 shows, it is include-angle phii of an incident ray. Include angle phi 0 of an outgoing radiation beam of light There is an equal property. If this optical fiber is arranged to two-dimensional as shown in drawing 4 , the direction of the beam of light from the photographic subject in an incidence end face will be reproduced by the outgoing radiation end face.
[0025] therefore, it is shown in drawing 1 -- as -- an outgoing radiation end-face side -- setting -- the same distance as the distance from an incidence edge to a photographic subject -- and a reconstruction image is acquired in the same magnitude as a photographic subject. As this condition was mentioned above, a playback stereoscopic model can be generated only behind the end face of an optical fiber 10, and cannot display a stereoscopic model on the front face of an optical fiber as an air image.
[0026] On the other hand, in order to display a stereoscopic model on the front face of an optical fiber, it is the die length Z0 of an optical fiber [0027]
[Equation 5]

$$Z_0 = \frac{\theta}{\sqrt{A}} = \frac{1}{\sqrt{A}} (2m + 1) \pi \quad \cdots (4)$$

m：ゼロ以上の整数

[0028] If it is alike and is corresponding die length, as shown in drawing 6 , it is set to r1 =−r2 and r'1 =−r'2, and is include−angle phii of an incident ray. Include angle phi 0 of an outgoing radiation beam of light A sign is reverse and an absolute value becomes equal.

[0029] Then, as shown in drawing 7 , when the beam of light which carried out outgoing radiation from the core of the end face of each optical fiber 10 is considered, it becomes the form which turned up the beam of light by the side of incidence to the symmetry at the incidence end face, and is the same distance d1 as an incidence edge to the photographic subject 11 in the travelling direction of light, i.e., the outside of an optical fiber 10. It crosses at a location. That is, a reconstruction image 12 is made on this intersection P.

[0030] In this case, unlike the conditions of the above−mentioned (3) formula, the light which came out from the whole surface of the end face of each optical fiber 10 advances with a certain breadth, as are shown in drawing 6 , and light was outputted from condensing [virtual] point P' by outgoing radiation one end. Triangle OO 1O3 by the side of [these things to] incident light Triangle P'P three P1 by the side of outgoing radiation light Triangle OO 1O3 by the side of incident light [/ reverse] Triangle O'O 1O3 symmetrical with a line Triangle P'P one P3 by the side of outgoing radiation light It turns out that it has become in collaboration. Therefore, the location P of the reconstruction image seen from condensing [virtual] point P' is 1 distance twice the distance of 2d of from condensing [virtual] point P' to the outgoing radiation edge of an optical fiber 10. This breadth since it is is the breadth D0 of the flux of light which comes out from the outgoing radiation side edge side of one optical fiber in a playback side. Twice as many 2D0 as this It becomes and becomes the part of this breadth, and the image which faded. However, this dotage does not pose a problem, when an end face is small.

[0031] after all, this condition is seen from the direction where a photographic subject is opposite, although a reconstruction image 12 will be acquired in the same magnitude as a photographic subject 11 −− things −− a sake −− irregularity −− having reversed −− a condition −− becoming . That is, the image (reconstruction image) which irregularity reversed on the outside of the outgoing radiation end face of an optical fiber 10 can be

obtained in the same magnitude as the same distance as a photographic subject and the distance to an incidence end face.

[0032] In this condition, since irregularity is reversed, as shown in drawing 8 , it is the description of this invention to set a certain amount of spacing for this optical-fiber group, and to cancel this irregularity by 2 sets or using even sets to a serial. If it is made for the image (the 1st image) which the 1st optical-fiber group 10-1 makes to be ahead of the input end face of the 2nd optical-fiber group 10-2 (that is, d2 is not made negative among drawing 8), as for the image (the 2nd image) which the 2nd optical fiber makes, irregularity will serve as a certain amount of spacing in this case with a right thing as an air image on the outside of an optical-fiber edge. That is, since a concavo-convex inversion takes place twice, irregularity serves as a right image as a result and the 1st, the fiber group 10-1 of 2, and 10-2 make an air image from the arrangement configuration of drawing 8 , a reconstruction image (the 2nd image) turns into an air image.

[0033] Moreover, as drawing 9 shows, it is [0034] of the optical fiber concerned.

[Equation 6]

$$\theta = \sqrt{A}\, z_0 = \left(m + \frac{1}{2}\right)\pi \qquad \cdots (5)$$

m : ゼロ以上の整数

[0035] When parallel light inputs into optical-fiber 10A by the side of **********, i.e., incidence, the magnitude of a playback stereoscopic model can be expanded compared with a photographic subject by inserting the expansion optical system 21 in the field which carries out image formation within the optical-fiber 10A concerned. Similarly, this expansion optical system can make small contraction optical system, then a playback stereoscopic model.

[0036] There is a fiber optic plate (Hamamatsu Photonics, Inc. product) etc. as these expansions and contraction optical system. Even in this case, all the die length of the optical fiber of the optical system concerned needs to fill the above-mentioned (4) formula.

[0037] Moreover, a stereoscopic model can also be rotated by replacing with the expansion optical system 21 what can rotate by the same fiber optical system (U.S.: INCOM product) as a fiber optic plate, and inserting in homotopic.

[0038] Furthermore, multiplication of the brightness of a display image can be carried out, or the fall of the brightness by transmission loss can be compensated with inserting optical multiplication equipments, such as an image intensifier, in the same

location.

[0039] (Other operation gestalten) Though natural, if it manufactures so that an optical-fiber group can be crooked, it will also become possible for the transmission line of this invention to be crooked again like invention of a Japanese Patent Application No. [which invention-in-this-application persons invented / No. 117355 / ten to] publication. For example, since each optical fiber itself is supple, the adjustment catch which binds only the both-ends location of an optical-fiber group tight, or adhesives can be attached, the condition that the outside of an optical-fiber group was crooked free can be held, for example, you may make it cover an optical fiber group by the wire of a shape memory alloy, a shape-memory resin, lead, or copper, rubber, the tube of the plastics of elasticity, etc.

[0040]

[Effect of the Invention] As explained above, according to this invention, the same merit who has a lens operation, and two or more optical fibers by considering as the optical-fiber group constituted so that it may become the same two-dimensional array at the both ends of the optical fiber concerned In an image pick-up and the solid image equipment transmitted and displayed, since the stereoscopic model was made into odd times of the half period of the optical path in an optical fiber, the die length of an optical fiber Being able to transmit a stereoscopic model covering a long distance without making light into an electrical signal, the stereoscopic model obtained turns into an air image located in the outside of an optical-fiber end face.

[0041] Moreover, according to this invention, a concavo-convex inversion is cancelable by setting a certain amount of spacing and using 2 sets of this optical-fiber group for a serial.

[0042] Moreover, according to this invention, by inserting the optical element of expansion, contraction, and rotation in the specific location in the middle of an optical fiber, a stereoscopic model can also be expanded, and it can also reduce and can also rotate. Multiplication of the brightness of a display image can be carried out, or the fall of the brightness by transmission loss can be compensated with furthermore inserting an optical multiplication component.

[0043] Moreover, it is also possible for the transmission line of this invention to be crooked.

[0044] Therefore, the solid image equipment by this invention is applicable as the endoscope which offers a solid image, a bore scope, etc.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the optical-path Fig. showing the situation of stereoscopic model playback of a publication by Japanese Patent Application No. No. 117355 [ten to] of point **.

[Drawing 2] It is the optical-path Fig. showing the principle-of-operation Fig. of an optical fiber.

[Drawing 3] It is the optical-path Fig. showing the incident ray and outgoing radiation beam of light of an optical fiber.

[Drawing 4] It is the conceptual diagram showing the optical-fiber group which carried out two-dimensional array of the optical fiber of a base unit.

[Drawing 5] It is the optical-path Fig. showing the example (theta=4pi) of optical-fiber length indicated by Japanese Patent Application No. No. 117355 [ten to] of point **.

[Drawing 6] It is the optical-path Fig. showing the relation between the incident ray in the solid image equipment of 1 operation gestalt of this invention, and an outgoing radiation beam of light.

[Drawing 7] It is the optical-path Fig. showing the relation between the photographic subject by one optical-fiber group, and a reconstruction image to the solid image equipment of 1 operation gestalt of this invention.

[Drawing 8] It is the optical-path Fig. showing the relation between the photographic subject by two optical-fiber groups, and a reconstruction image to the solid image equipment of 1 operation gestalt of this invention.

[Drawing 9] It is the block diagram showing expansion of the playback stereoscopic model in the solid image equipment of 1 operation gestalt of this invention.

[Description of Notations]

10 Optical Fiber

10-1, 10-2 Optical-fiber group

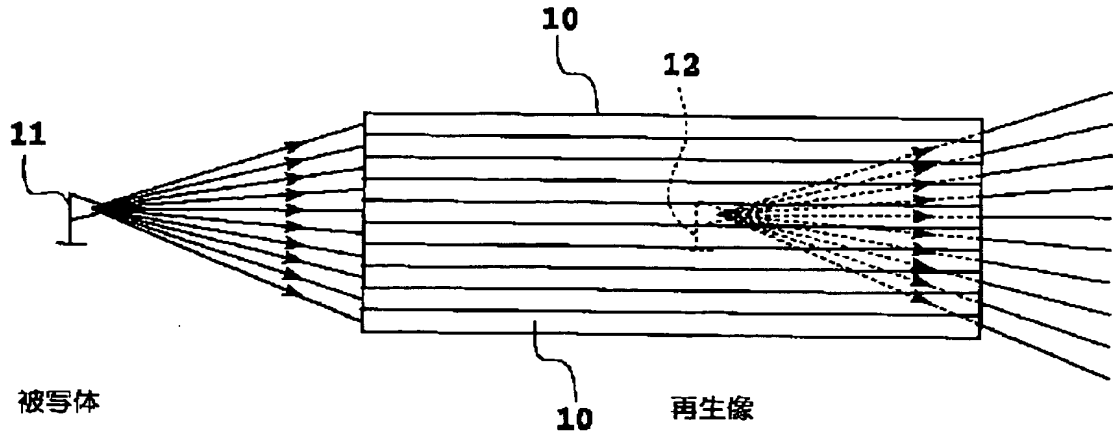
11 Photographic Subject

12 Reconstruction Image

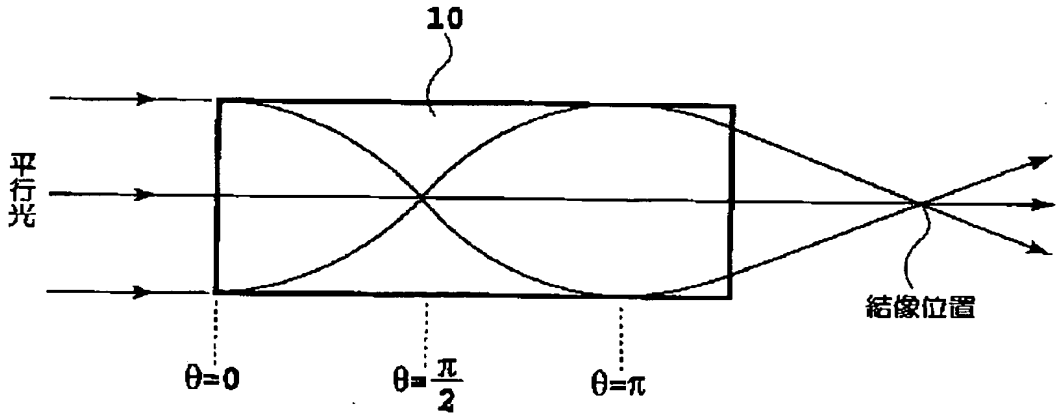
21 Expansion Optical System

DRAWINGS

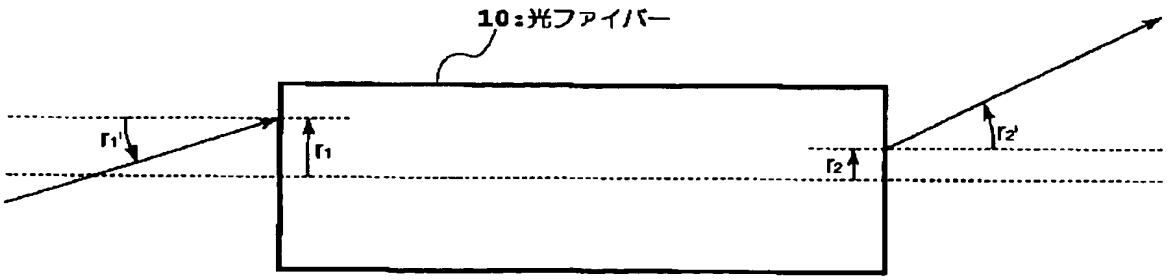
[Drawing 1]



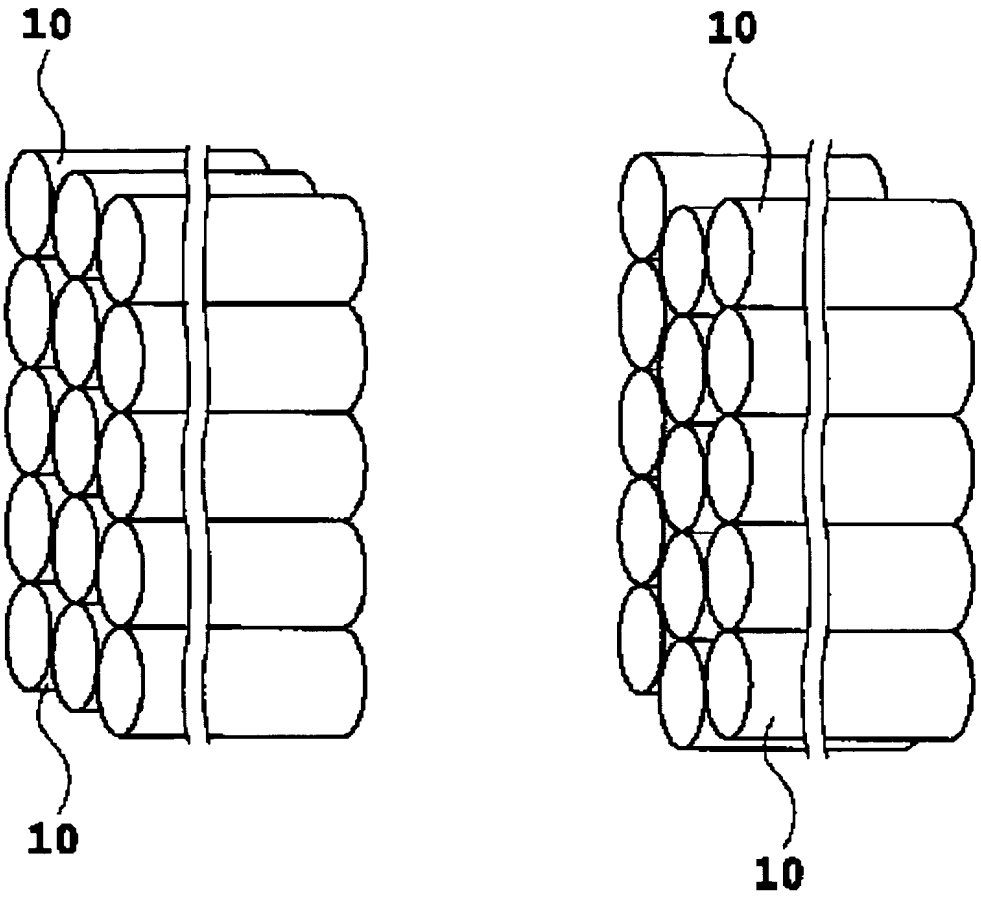
[Drawing 2]



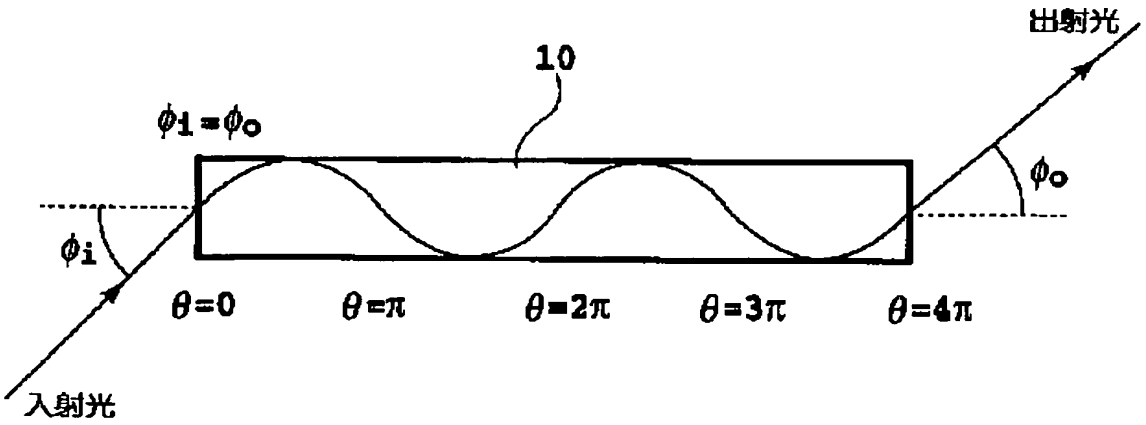
[Drawing 3]



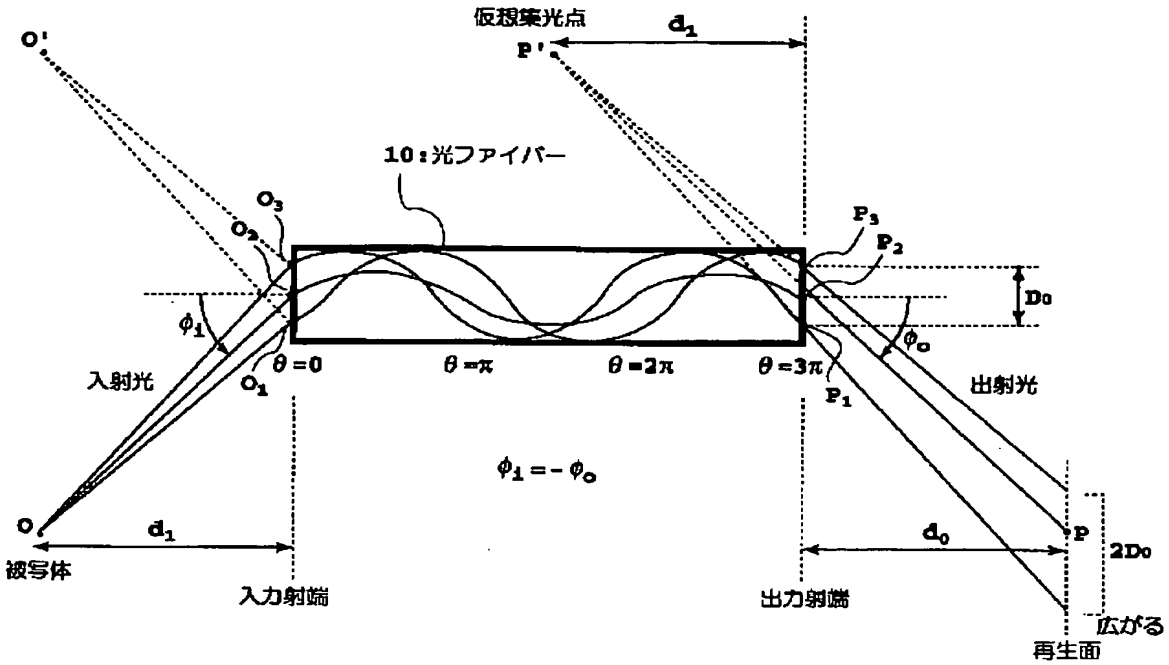
[Drawing 4]



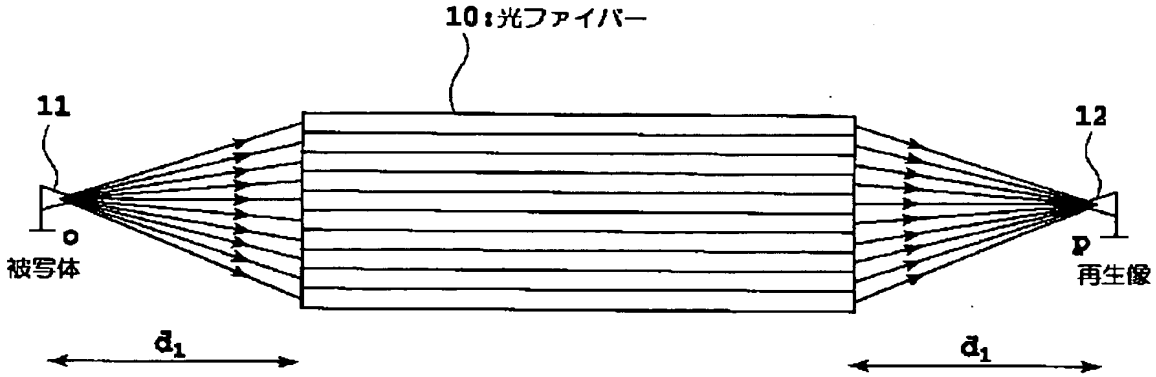
[Drawing 5]



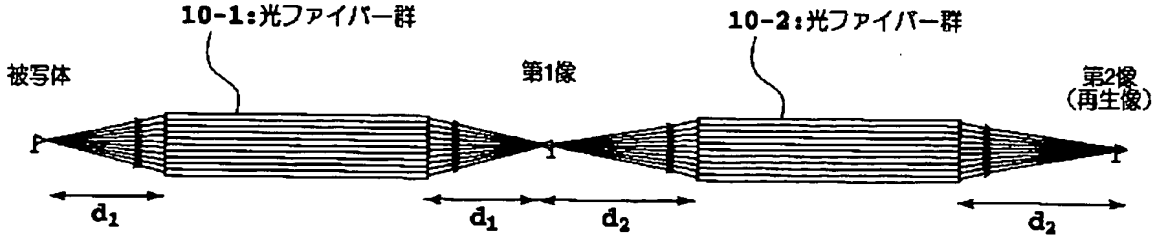
[Drawing 6]



[Drawing 7]



[Drawing 8]



[Drawing 9]